PYROTECHNIC SHOCK SIMULATION

MIDTERM I PROGRESS PRESENTATION

2/18/16

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Instructors: Dr. Gupta & Dr. Shih

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PROJECT BACKGROUND

- Pyrotechnics are used for tasks such as rocket separation, pilot ejection, airbag inflation, and payload deployment
- Can be damaging to sensitive electronic hardware
- Important to simulate in order to make sure other components are not damaged.
- Not easy to simulate
    - High Frequency
    - High Acceleration
    - Short Duration
    - Transient Response

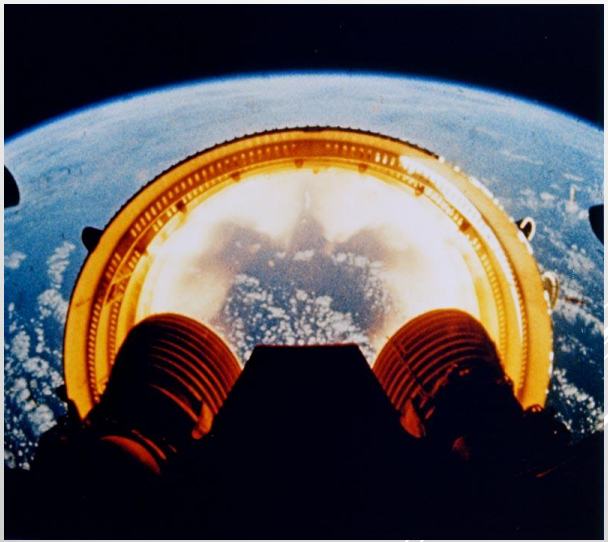


Figure 1: Rocket Separation

PROJECT BACKGROUND

- Actual pyrotechnics are not required to simulate similar shock responses
- Shock response is difficult to analyze in the time domain
- Shock Response Spectrum (SRS): Describes the shock response in the frequency domain

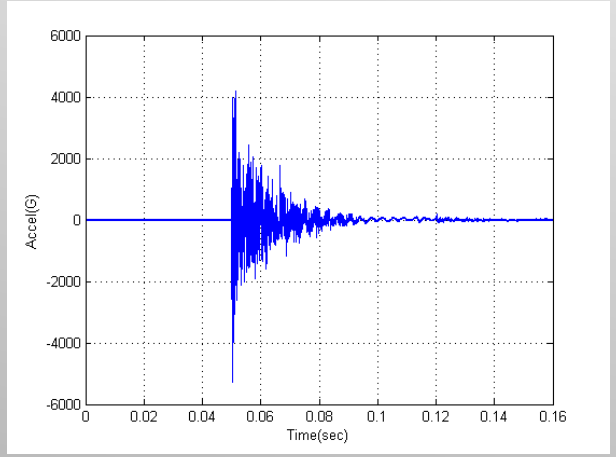


Figure 2: Example shock response in the time domain

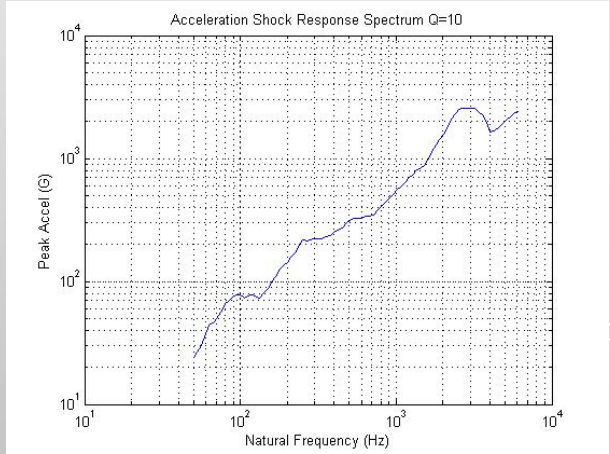


Figure 3: Example SRS curve in the frequency domain

PROJECT BACKGROUND

- SRS curves are generated from the acceleration time history of the shock response
- Models the system as an array of single-degree-of-freedom (SDOF) systems
- The maximum acceleration is mapped to each frequency, yielding the SRS curve

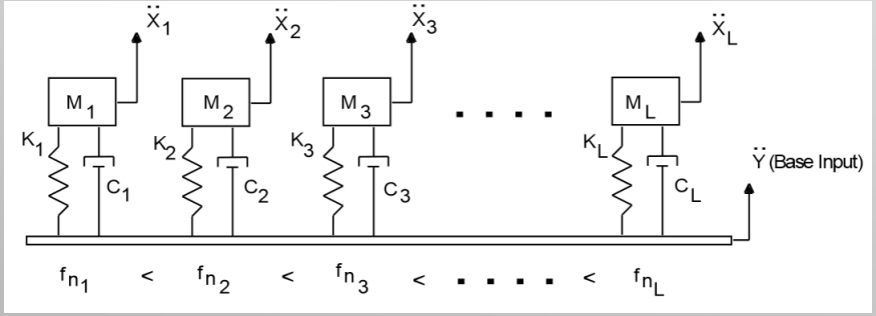


Figure 4: Array of SDOF systems with every possible natural frequency

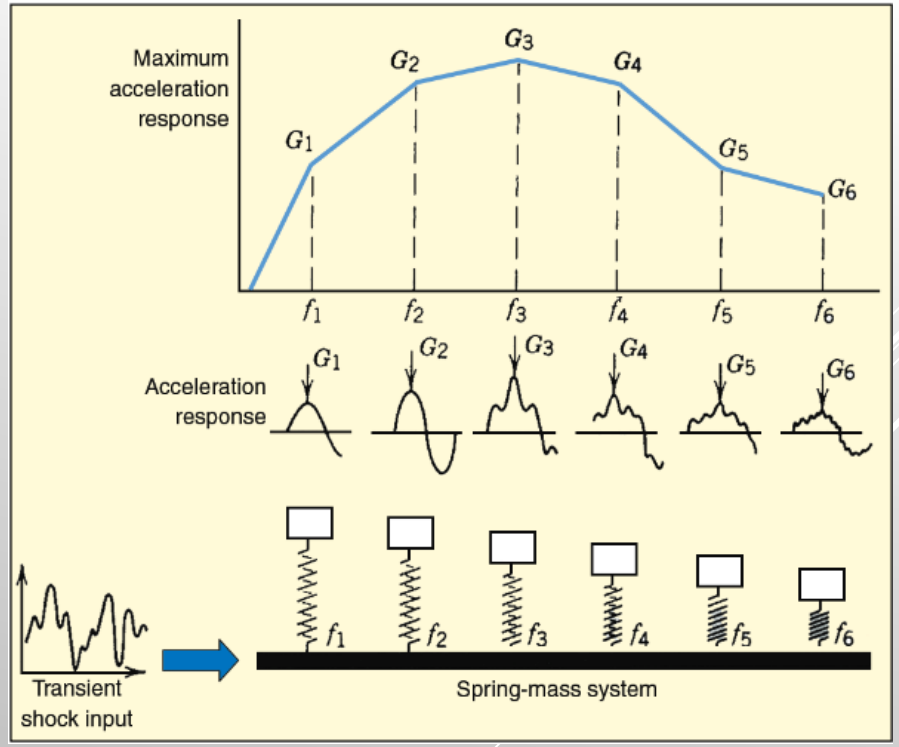


Figure 5: How SRS curves are generated

PROJECT SCOPE

What does Harris want?

- Harris simulates pyrotechnic shock, but they don't have time to manipulate variables to find the desired result.
- Want understanding of how different variables affect SRS in order to predict results.

How to accomplish this?

- Build device to simulate pyrotechnic shock.
- Run tests to correlate variables with changes in SRS curve.

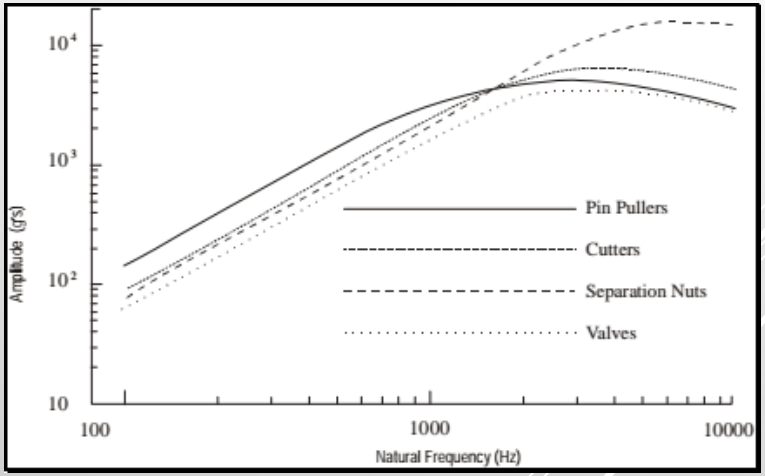


Figure 6: Harris SRS curves for different pyrotechnics

PROJECT SCOPE

- Two Year Project
  - Year 1 – Design and build test rig and data acquisition system.
  - Year 2 – Implement design changes to create repeatability and collect data for variable pyroshock simulation.
- Need Statement

  Collect data that demonstrates correlation between variables and SRS curve output
- Project Goals
  - Modify design to create repeatability in results
  - Design experiments to test variables and resulting curves
  - Possibly improve efficiency of data acquisition process

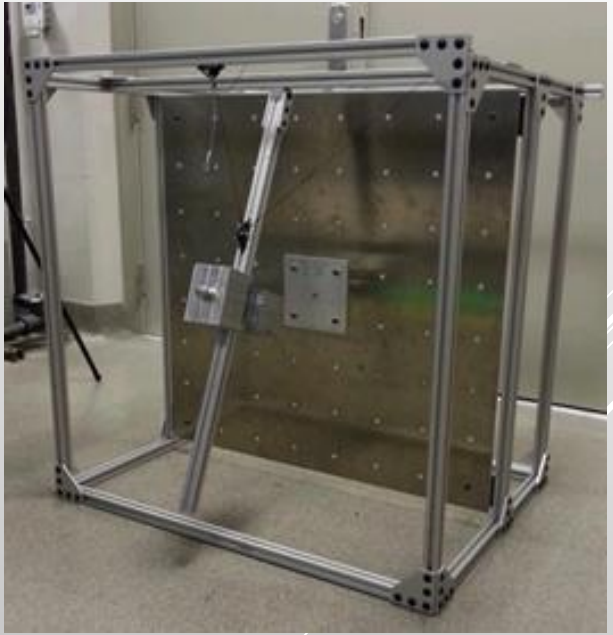


Figure 7: Testing Apparatus

DESIGN IMPLEMENTATIONS

Things to be changed in order to create repeatable data:

- Anchor
- Change Pivot
- Decouple from frame
- Sacrificial plate adjustment

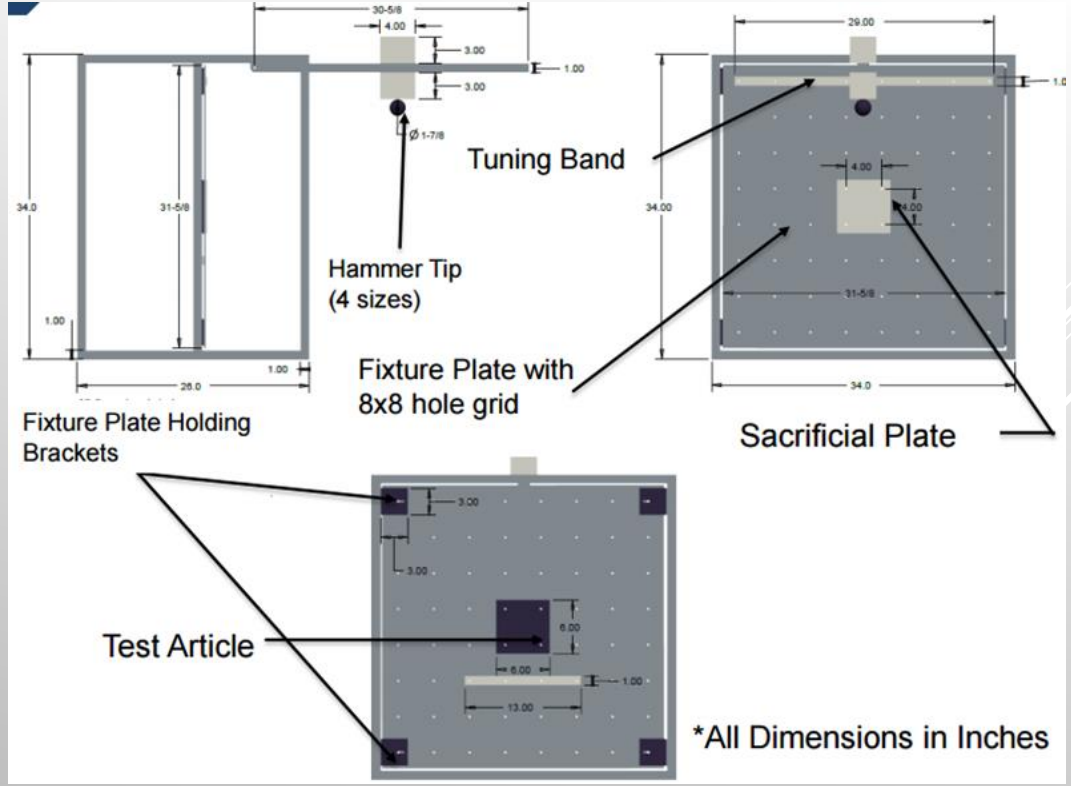


Figure 8: Apparatus Dimensions

ANCHORING

- Newport series instrumentation table
- 528lb
- Aluminum two hole strap
- Foam for equivalent force distribution.

Figure 9: Simulation Table and Mounts

ANCHORING

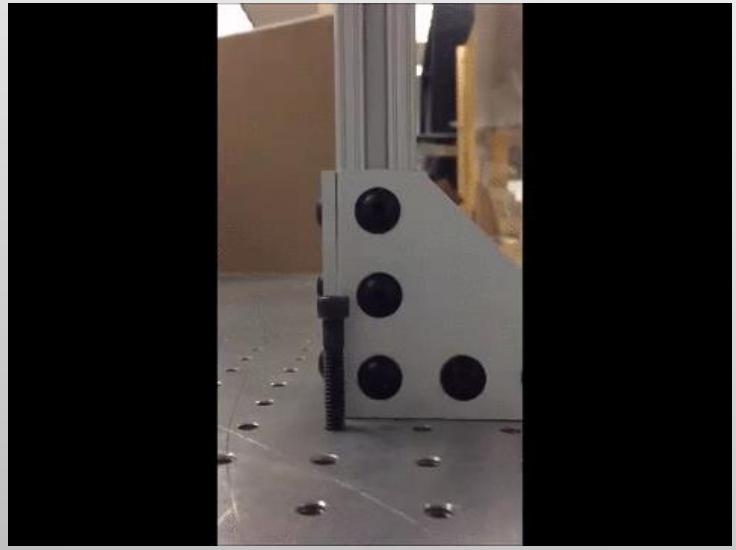


Figure 10: Un-anchored Test

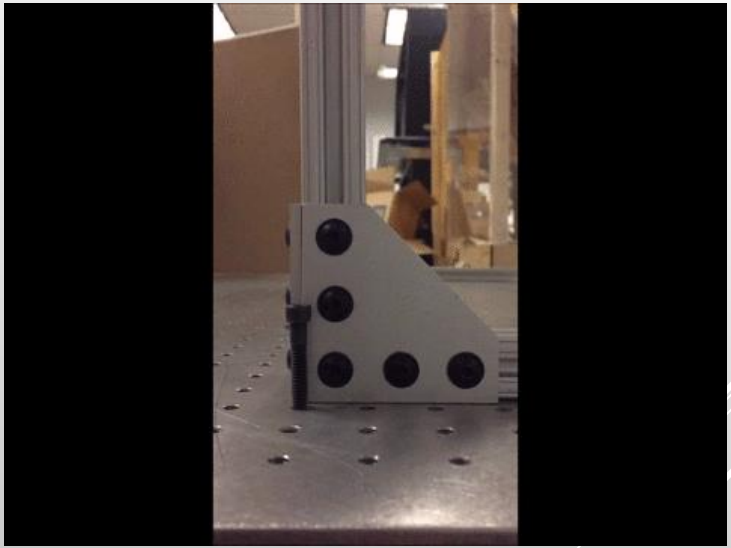


Figure 11: Anchored Test

PIVOT REPLACEMENT

- Previous pivot was a static pivot mount
  - This caused wear and unwanted side to side motion.
- New pivot is a dynamic pivot with lubricated bronze bushings

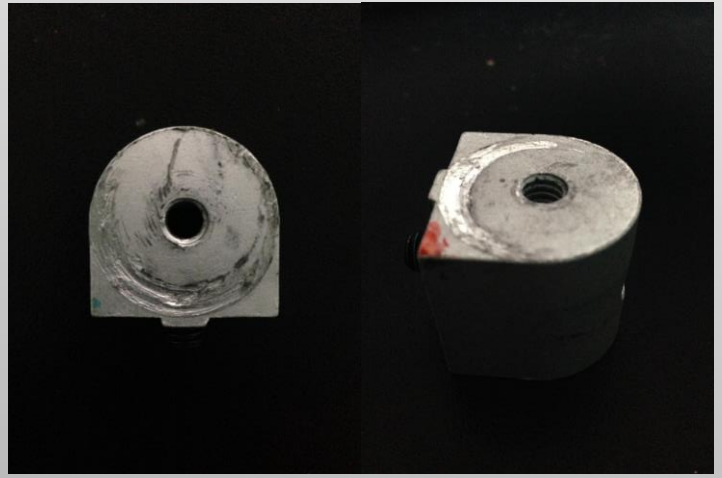


Figure 12: Wear Static Pivot

Figure 13: Dynamic Pivot

DECOUPLING PROPOSALS

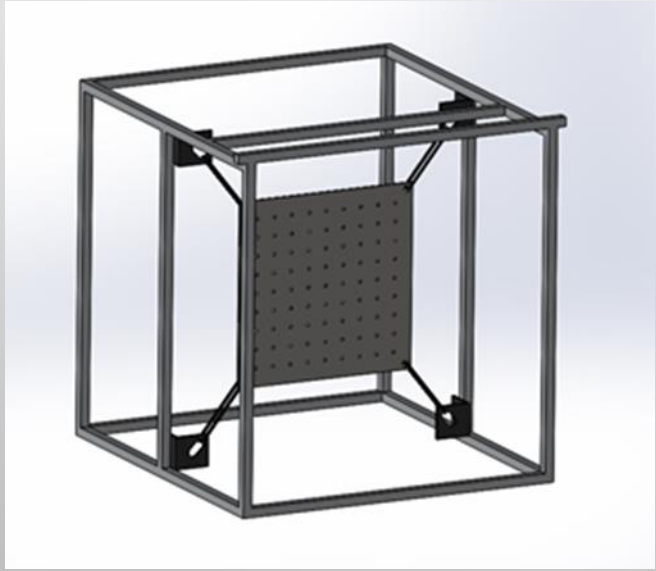


Figure 14: Tethered Suspension Design

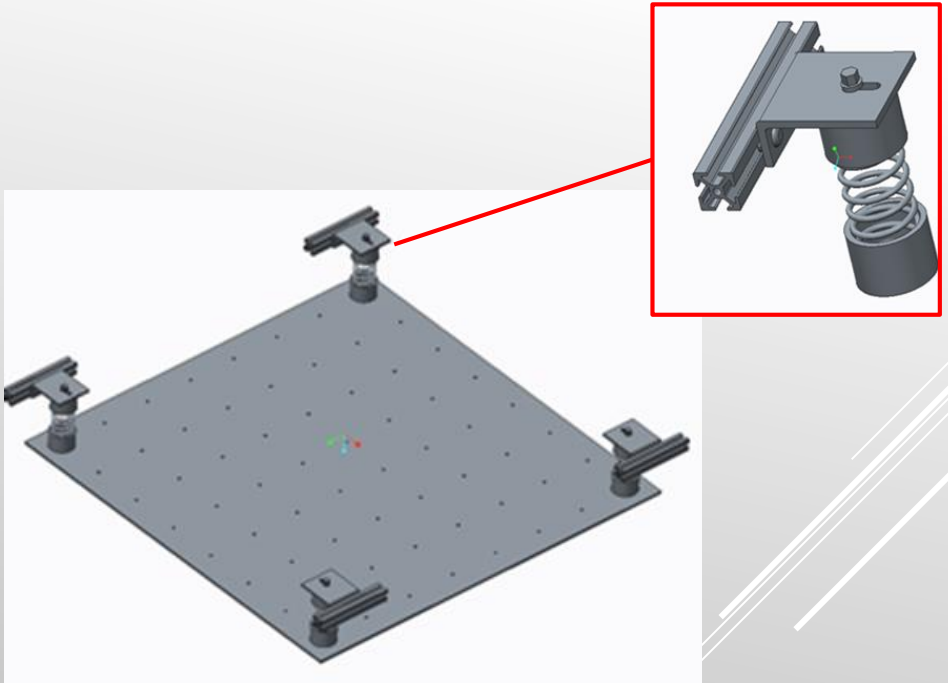


Figure 15: Spring Suspension Design

CURRENT SETUP

- National Instruments DAQ (USB - 6211)
  - 16 Bit
  - Max Frequency - 80 MHz
- PCB Signal Conditioner (model 485A21)
- Dytran Current Limiting Power Source (model 4110C)
- Dytran Accelerometer (model 3086A4T)

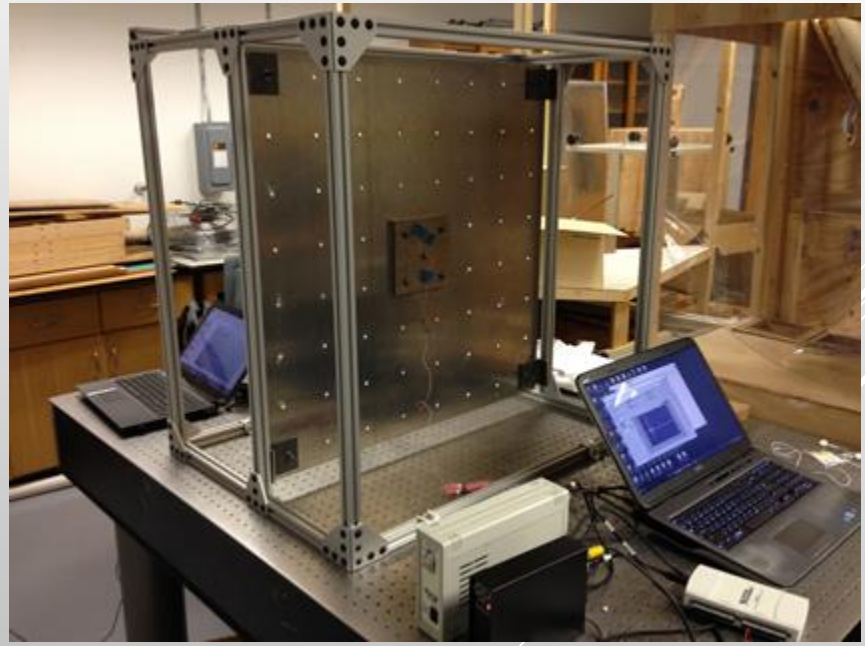


Figure 16: Test Apparatus and Equipment

DATA COLLECTION

- New DAQ presents 60Hz spike
- Discovered grounding issue
- Grounded the DAQ and eliminated the spike.

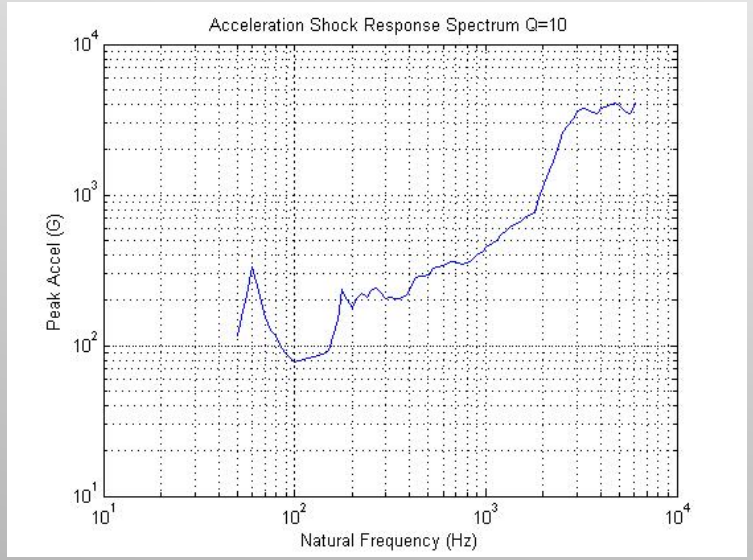


Figure 17: Ungrounded Test Result

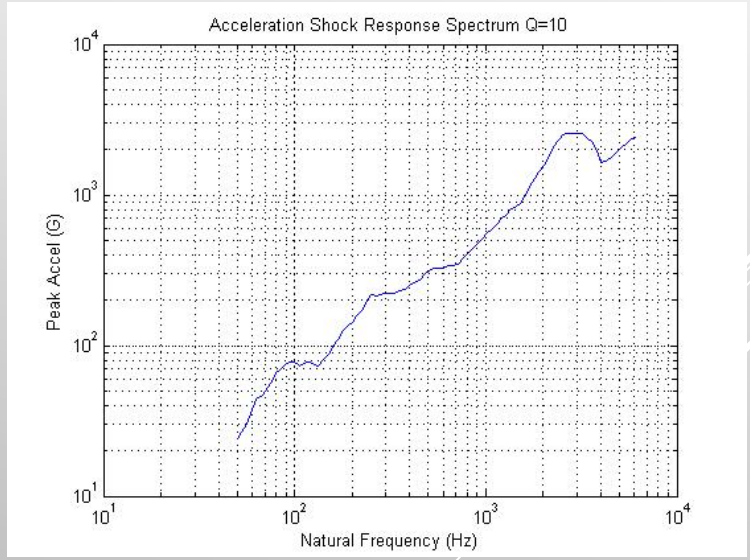


Figure 18: Grounded Test Result

DATA COLLECTION

- Initial runs more successful than anticipated
- Repeatability good enough to reconsider decoupling

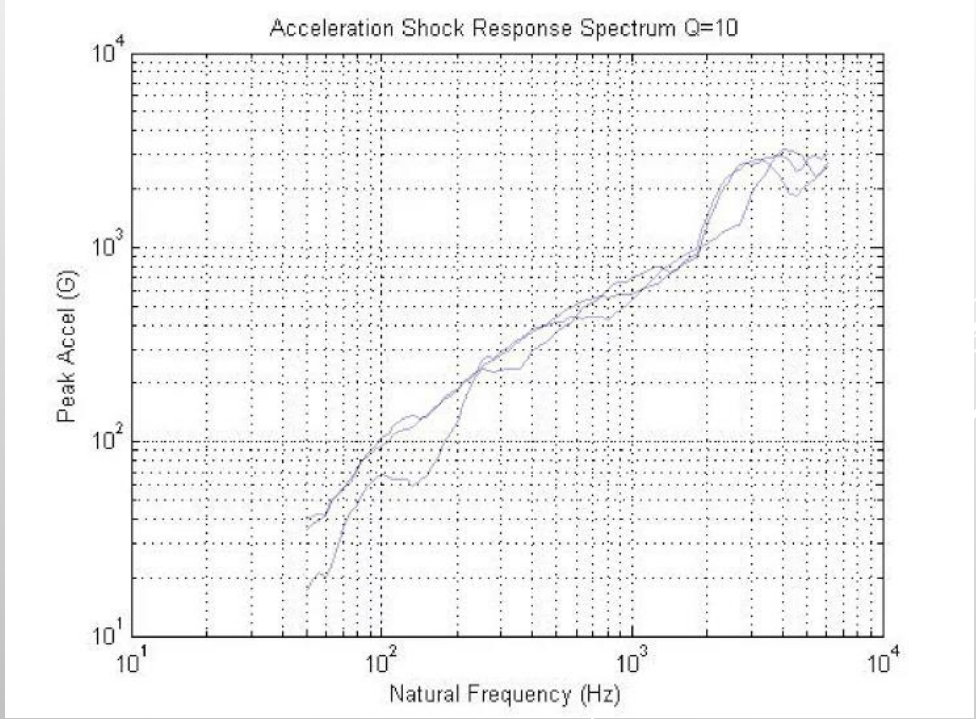


Figure 19: Initial Test Runs

DECOUPLING

- Rubber pads between plate and L bracket
- Rubber washer between screw head and plate
- Theoretically isolates test plate from frame

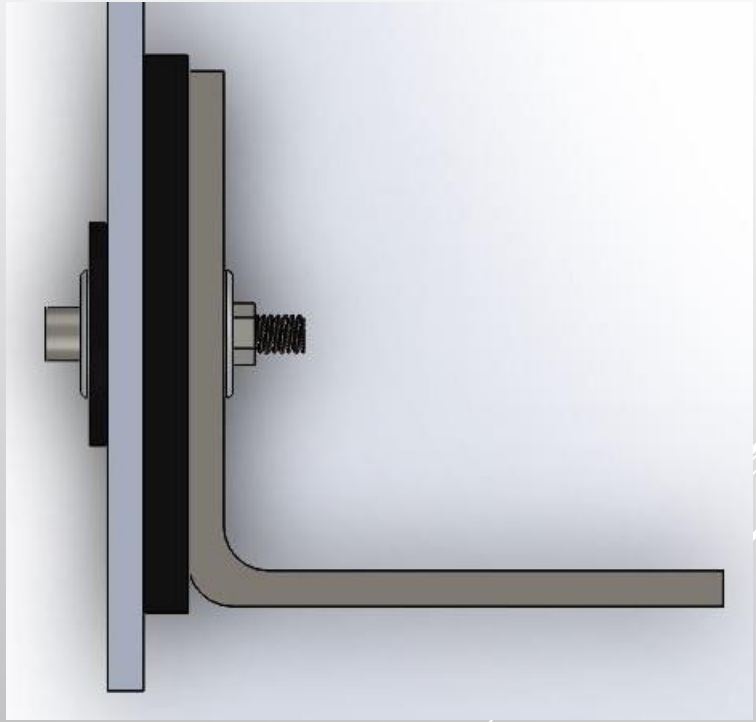


Figure 20: Simple CAD Model of Rubber Dampening

DATA COLLECTION

- Less variance between curves
- Very tight section just over 1000Hz
- Able to move forward into variable testing

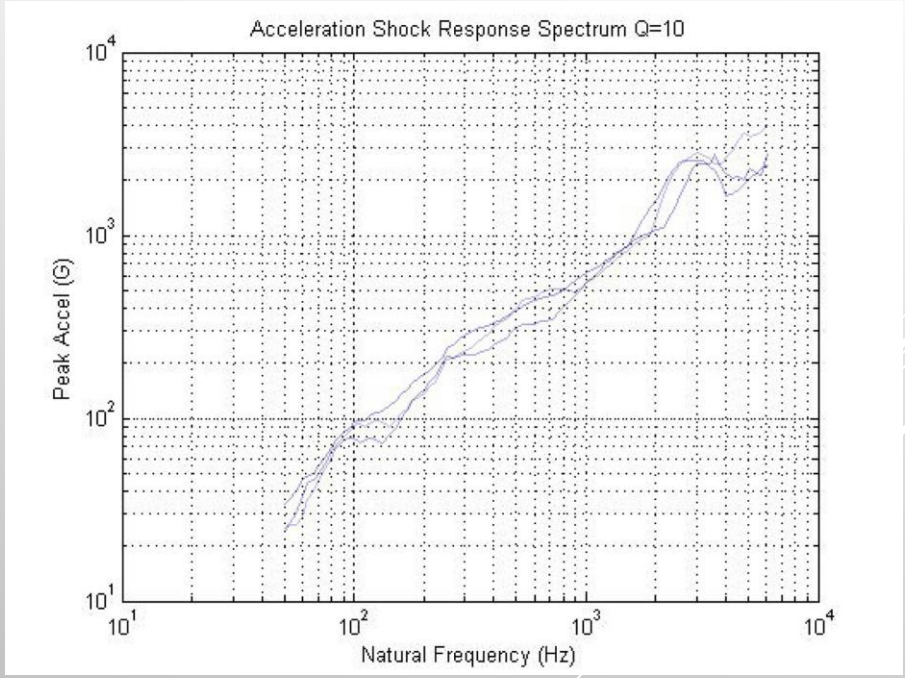


Figure 21: Most Recent Graph Overlays

DATA COLLECTION

- Getting second disturbance which we would like to eliminate
- Most likely caused by the sacrificial plate rebounding

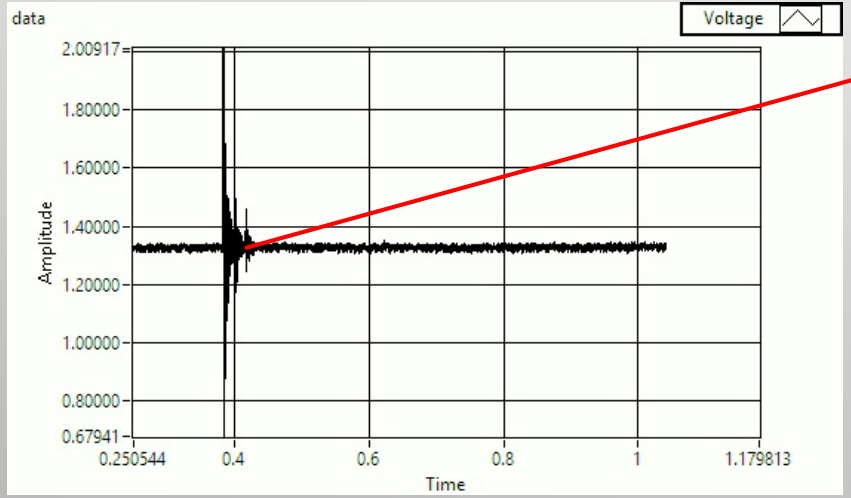


Figure 22: Raw Data with Disturbance

DATA COLLECTION

- Sacrificial plate is separating from the test plate and then slapping against it again.
- Possibly eliminate by applying lubricant between plates to create vacuum.

Figure 23: Slow-Mo of Plate Seperation

REPEATABILITY

- -3dB to +6dB over minimum 90% of SRS Curves
- Remaining 10% within -6dB to +9dB

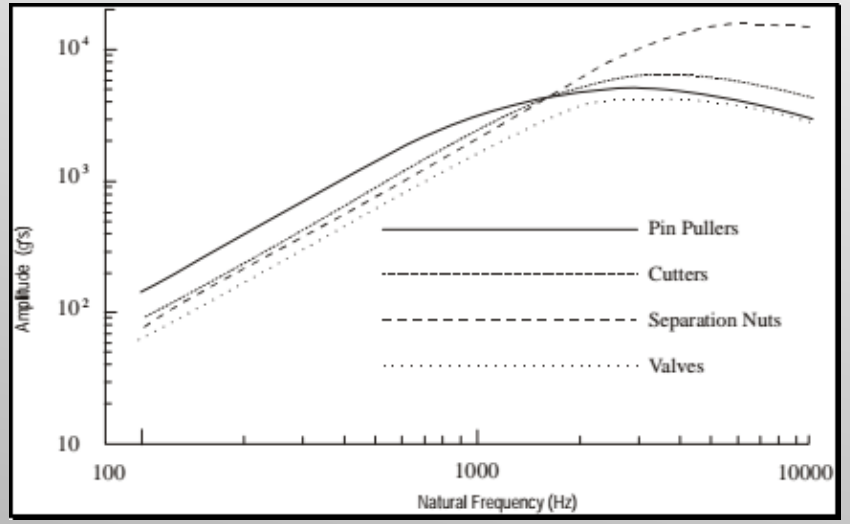


Figure 24: Harris Theoretical SRS Data

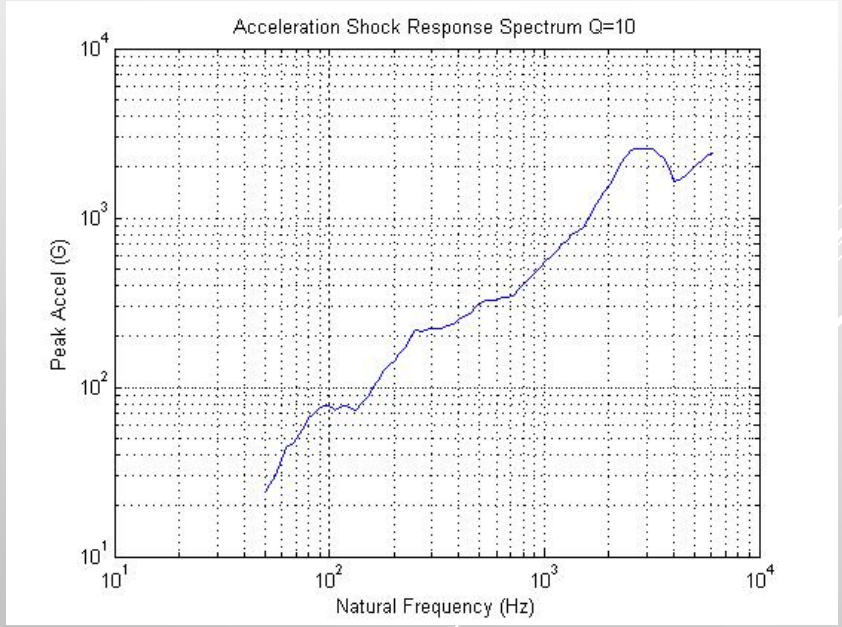


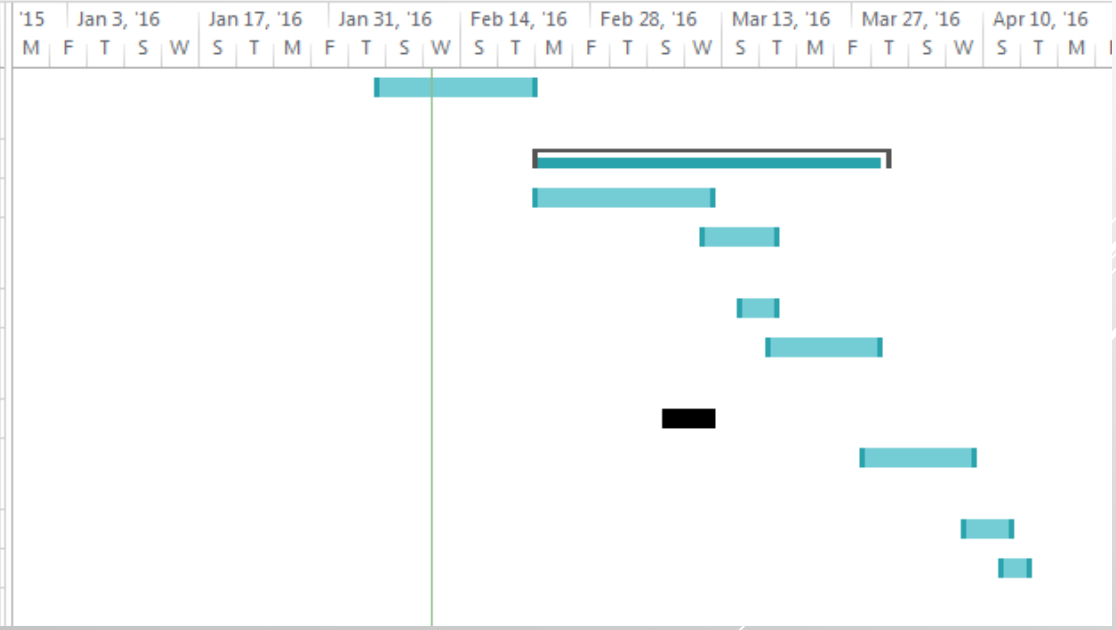
Figure 25: Experimental Results

PLANS FOR THE FUTURE

- Run tests with lubricant between sacrificial plate and test plate
- Design experiments with changing various parameters, collect shock response data, and generate new SRS curves
- Identify how to tune fixture to achieve desired SRS results; this requires an understanding of the relationship between various fixture parameters and the resulting changes in the SRS curves.
- Abaqus modeling of stress locations

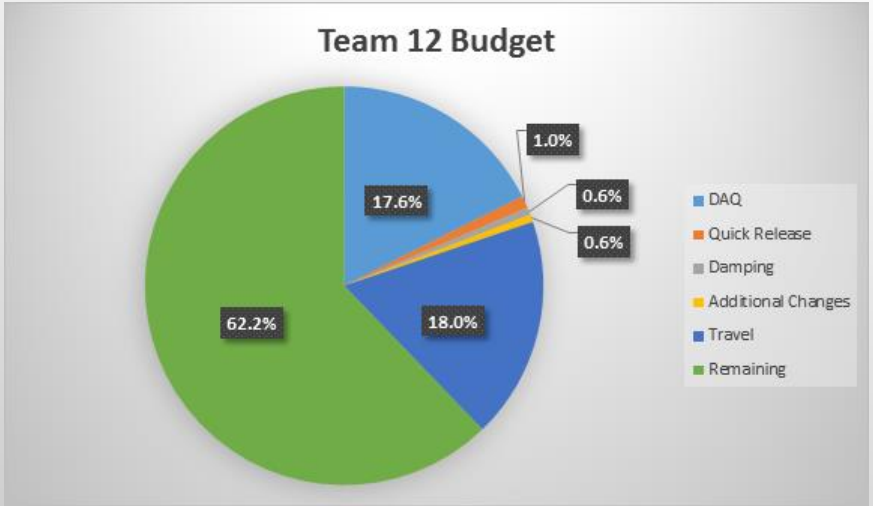
GANTT CHART

Task Name	Duration	Start	Finish
Improving Repeatability	12 days	Fri 2/5/16	Sun 2/21/16
Design of Experiments	**28 days**	**Mon 2/22/16**	**Wed 3/30/16**
Run Experiments	15 days	Mon 2/22/16	Fri 3/11/16
SRS Generation and Abaqus	6 days	Fri 3/11/16	Fri 3/18/16
Analyze Conclusions	4 days	Tue 3/15/16	Fri 3/18/16
Changes/Reruns (if necessary)	8 days	Fri 3/18/16	Tue 3/29/16
Spring Break	5 days	Mon 3/7/16	Fri 3/11/16
Finalize Conclusions/Documents	10 days	Mon 3/28/16	Fri 4/8/16
Additional Goals	3 days	Fri 4/8/16	Tue 4/12/16
Wrap Up Project	3 days	Tue 4/12/16	Thu 4/14/16



FINANCES

- Well within budget provided for this project
- Majority Spent on DAQ purchase
- Remaining purchases mostly used for travel



Initial Budget (AME): $5000			
Items	**Cost**		**Remaining**
DAQ	$880.00	*bought*	$4,120.00
Quick release (& supplies)	$50.00	*estimated*	$4,070.00
Damping supplies	$30.00	*estimated*	$4,040.00
Additional parameter changes	$30.00	*if necessary*	$4,010.00
Travel to Harris	$900.00	*estimated*	**$3,110.00**

QUESTIONS?

REFERENCES

"Pyro Shock Testing." Pyroshock Testing Simulation & Techniques. National Technical Systems, Inc., 2015. Web. 27 Oct. 2015. <https://www.nts.com/services/dynamics/shock/pyro_shock>.

DeMartino, Charles, Nathan Crisler, Chase Mitchell, and Chad Harrell. Pyrotechnic Shock Test Development - Midterm II Presentation Tech. no. 1. Tallahassee: FAMU-FSU College of Engineering, 2014.

Wells, Robert. "Conference Call with Mr. Wells, Mrs. Cooper, and Mr Cornejo." Teleconference interview. 12 Nov. 2015.